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Komuro et al.

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(54) **SURGICAL ASSISTANT SYSTEM**

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(JP)

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(JP)

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(52) **U.S. Cl.**

CPC . **G06F 3/01** (2013.01); **A61B 17/29** (2013.01);
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A61B 1/0005; A61B 19/5225; A61B 1/00149;
A61B 5/742; G06T 2207/10068
USPC 600/102
See application file for complete search history.

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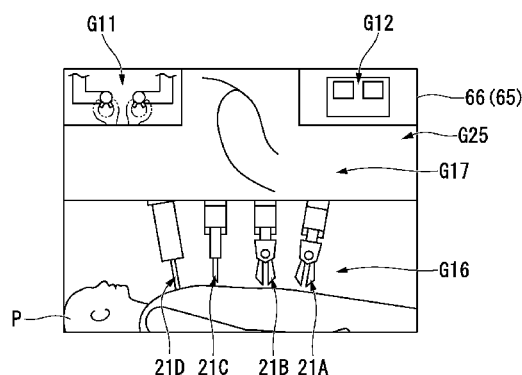
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Presser, PC

(57)

ABSTRACT

A surgical assistant system includes: an operation unit configured to give an input; an arm unit on which a treatment tool is mounted; an operation imaging unit configured to acquire an operation image that is an image including the operation unit; an endoscope configured to acquire an internal-body image; a mode control unit having a plurality of operation modes and configured to enable one of the plurality of operation modes to be set as a setting operation mode; a driving unit configured to enable the arm unit to be operated based on the input given by the operation unit and the setting operation mode; a synthetic image creation unit configured to synthesize images using at least the operation image to create a synthetic image based on the setting operation mode; and a display unit configured to display the synthetic image.

11 Claims, 9 Drawing Sheets



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- A61B 18/14** (2006.01)
- A61B 19/08** (2006.01)
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- A61B 17/068** (2006.01)
- A61B 19/10** (2006.01)
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- (52) **U.S. Cl.**
- CPC **A61B 18/1402** (2013.01); **A61B 19/081** (2013.01); **A61B 19/22** (2013.01); **A61B 19/2203** (2013.01); **A61B 19/26** (2013.01); **A61B 19/44** (2013.01); **B25J 13/02** (2013.01); **A61B 17/068** (2013.01); **A61B 19/10** (2013.01); **A61B 19/5244** (2013.01); **A61B 19/56** (2013.01); **A61B 2017/00119** (2013.01); **A61B 2017/00477** (2013.01); **A61B 2017/00482** (2013.01); **A61B 2019/2223** (2013.01); **A61B 2019/2269** (2013.01); **A61B 2019/2292** (2013.01); **A61B 2019/2296** (2013.01); **A61B 2019/465** (2013.01); **A61B 2019/467** (2013.01); **A61B 2019/4815** (2013.01); **A61B 2019/4868** (2013.01); **A61B 2019/4873** (2013.01); **A61B 2019/5255** (2013.01); **A61B 2019/5289** (2013.01); **Y10S 901/08** (2013.01); **Y10S 901/09** (2013.01); **Y10S 901/30** (2013.01); **Y10T 29/49826** (2015.01); **Y10T 74/18056** (2015.01)
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FIG. 1

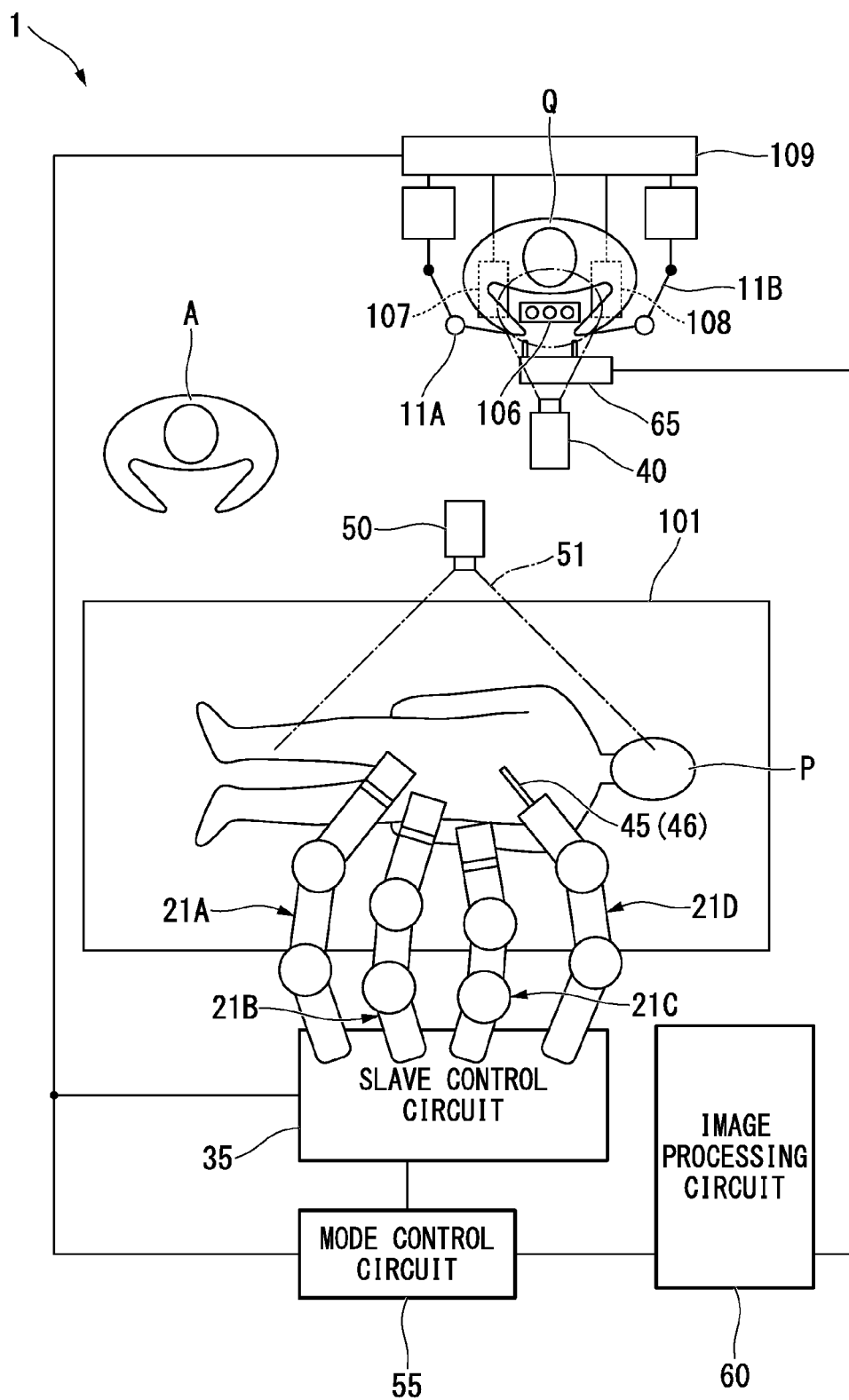


FIG. 2

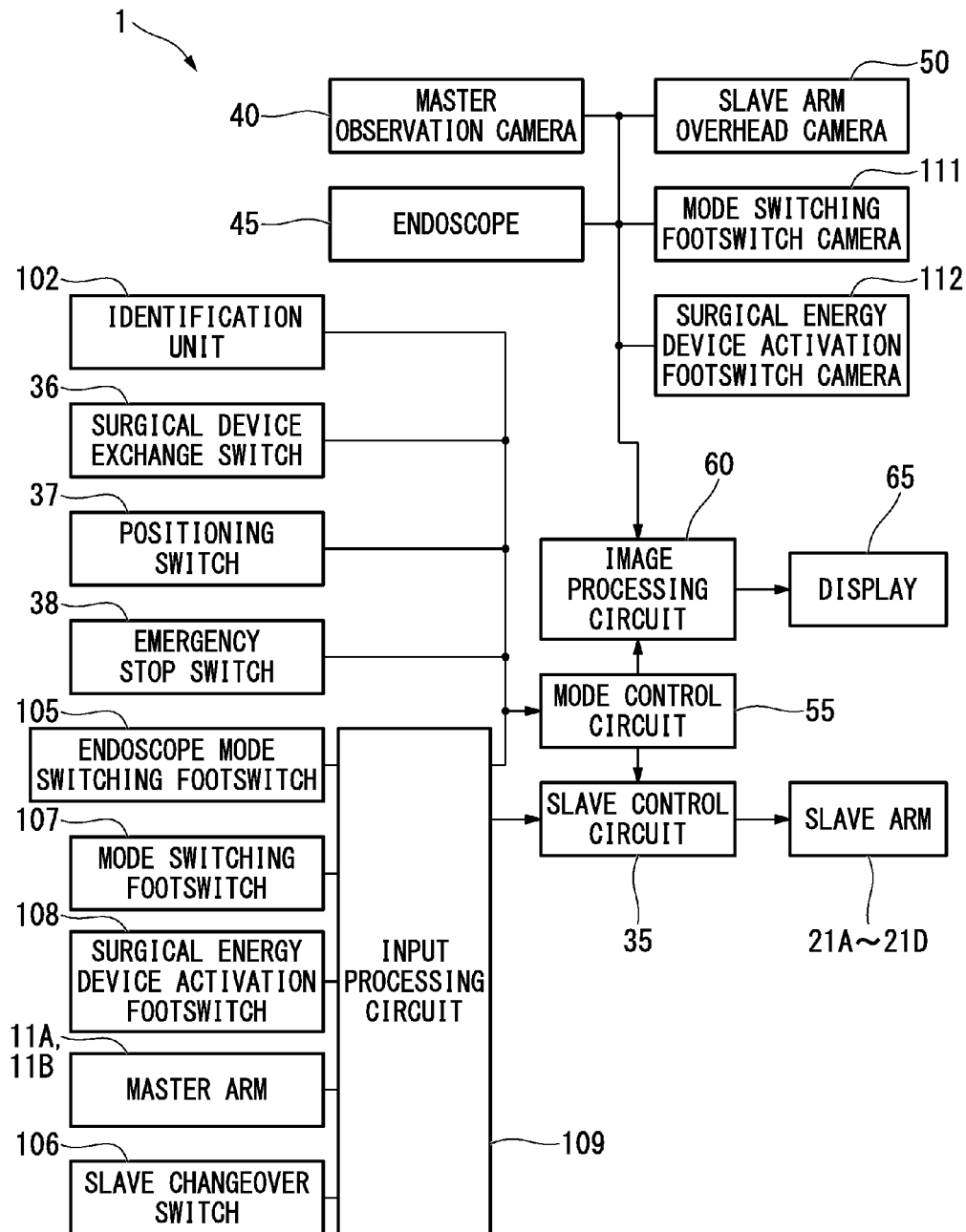


FIG. 3

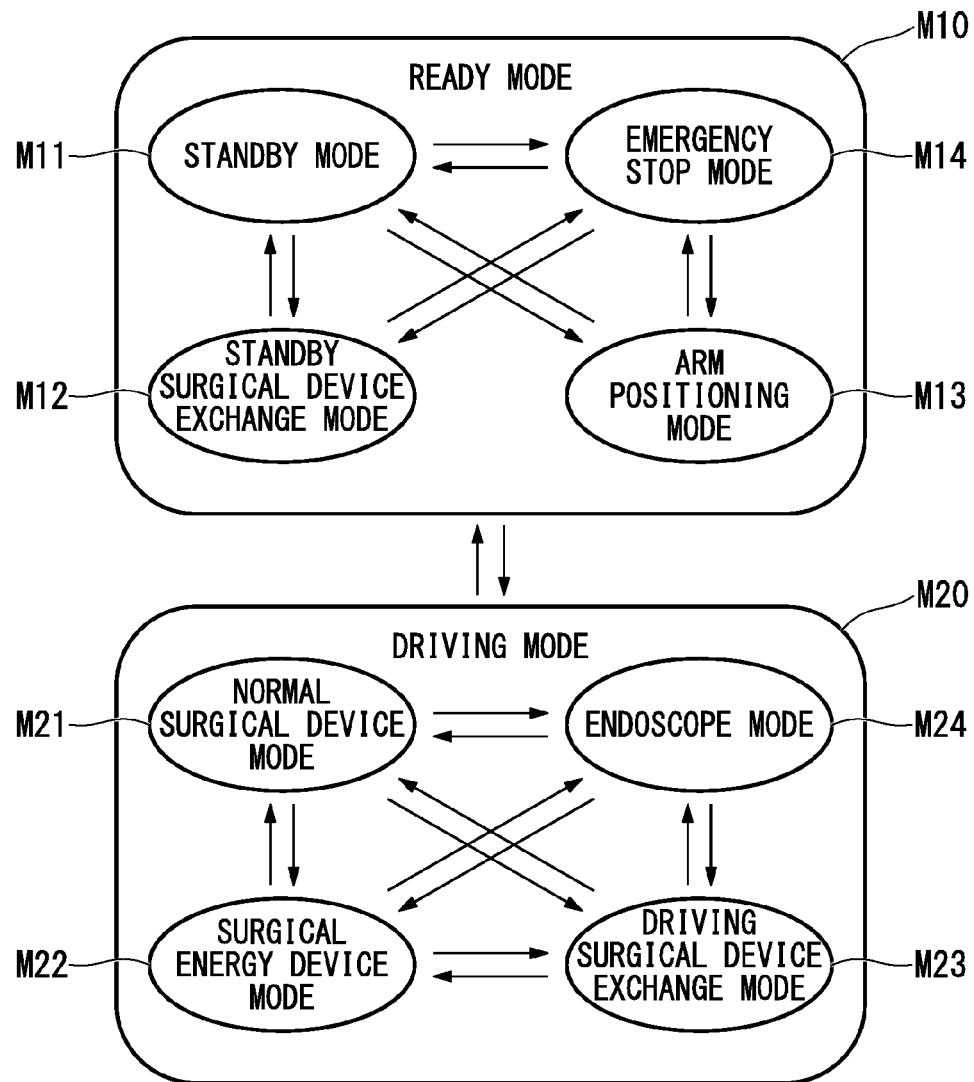


FIG. 4

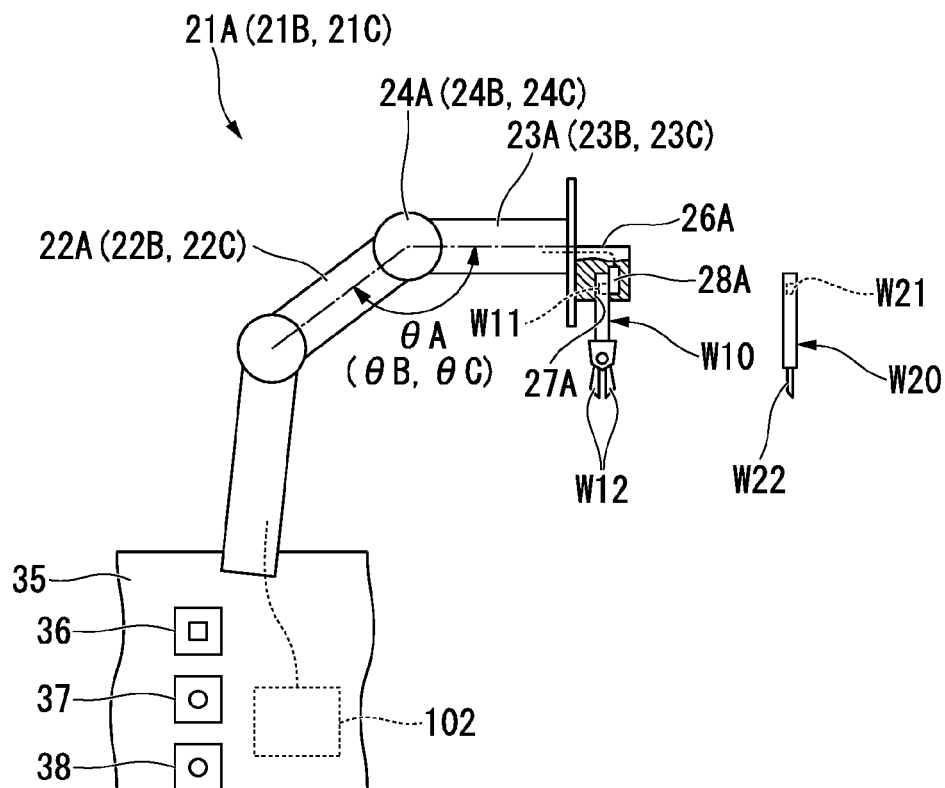


FIG. 5

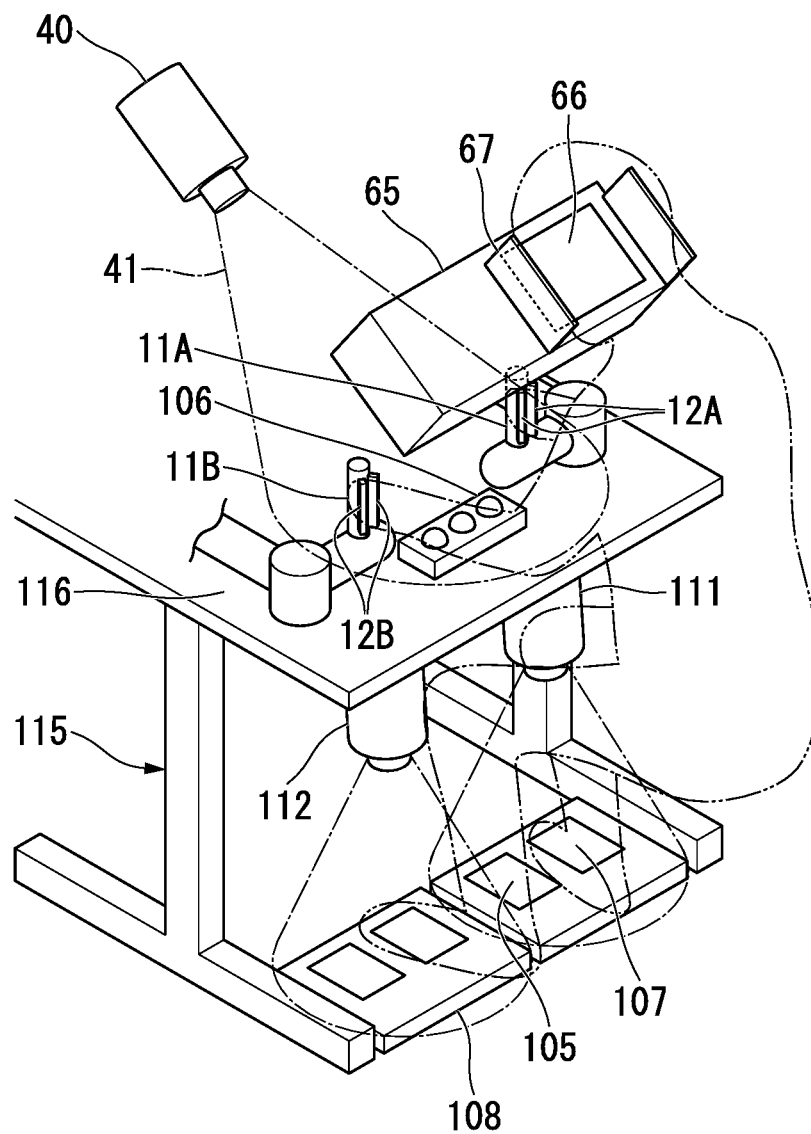


FIG. 6

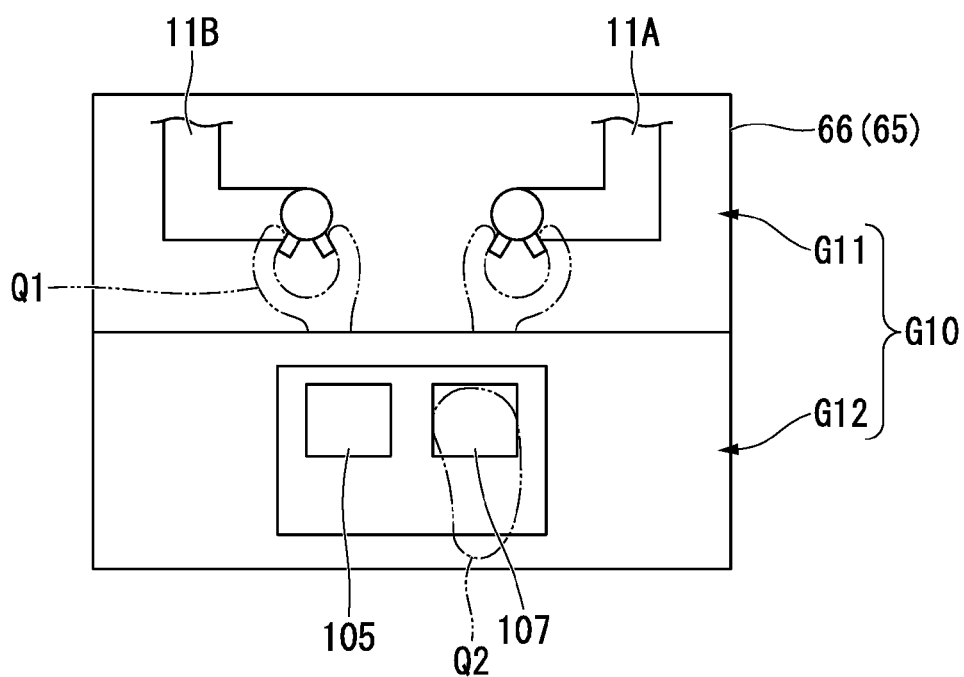


FIG. 7

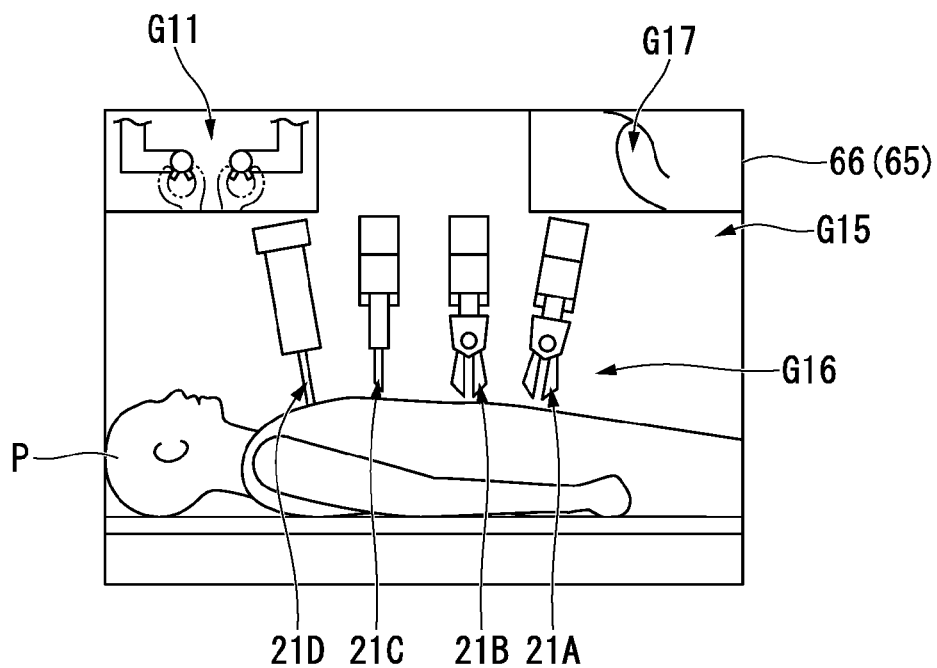


FIG. 8

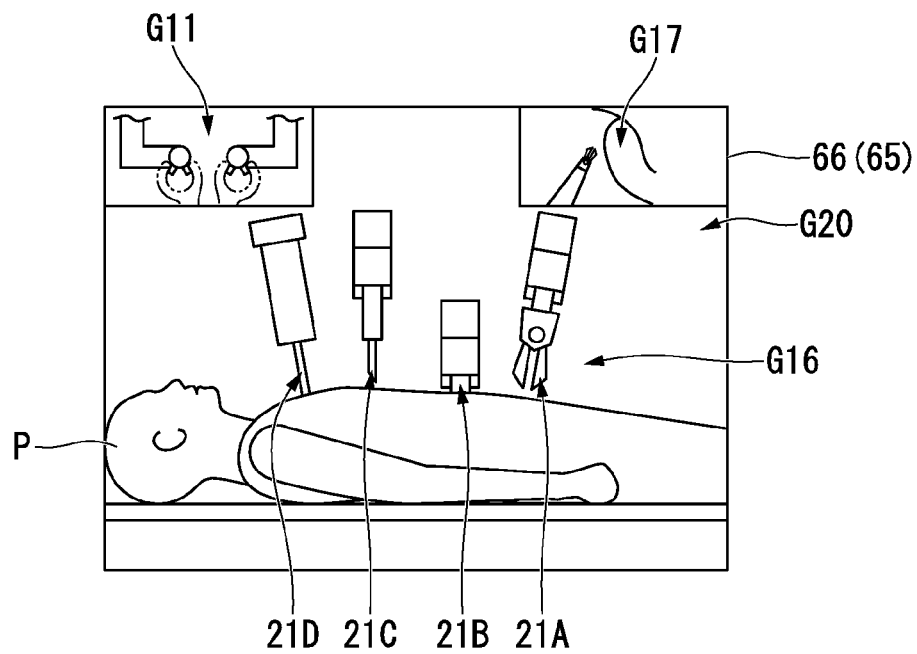


FIG. 9

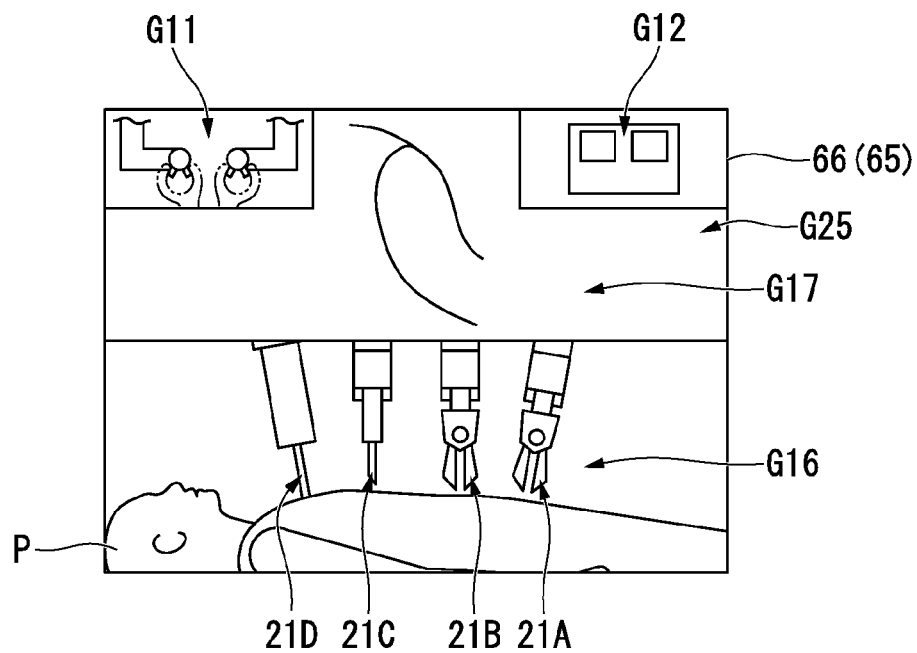


FIG. 10

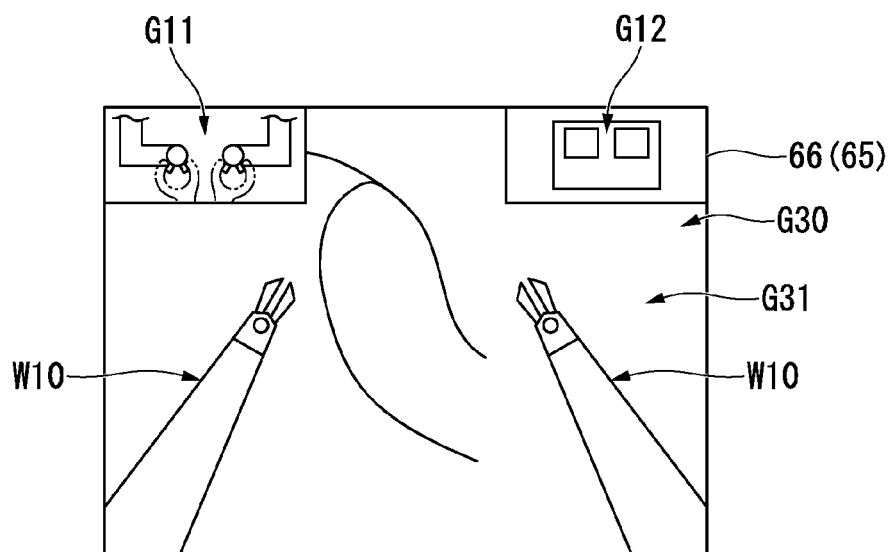


FIG. 11

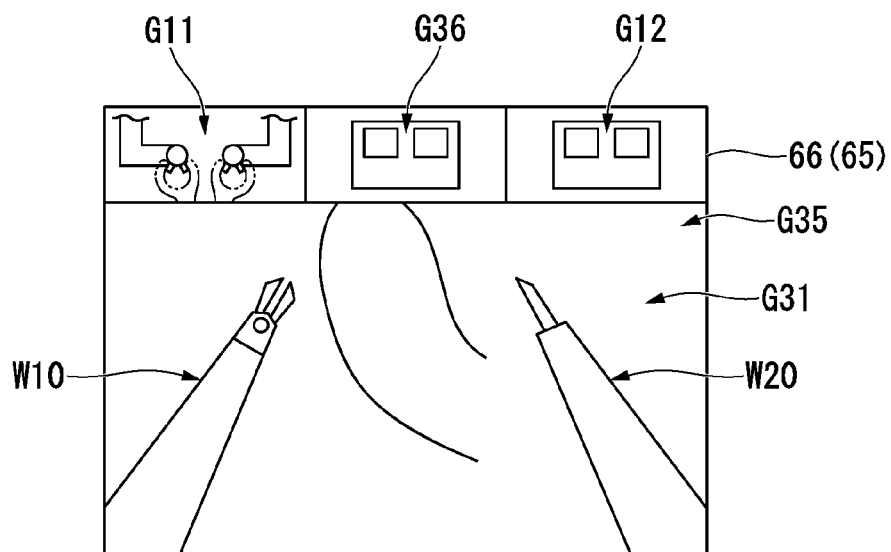


FIG. 12

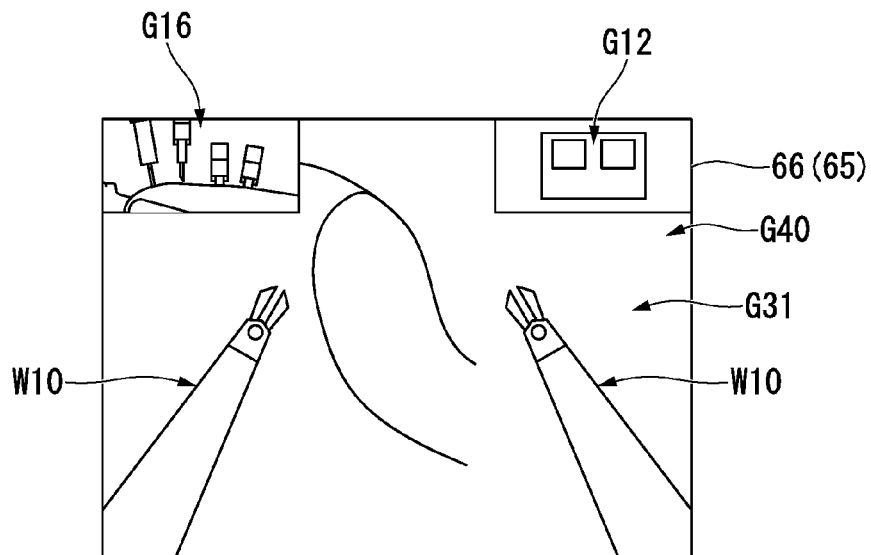
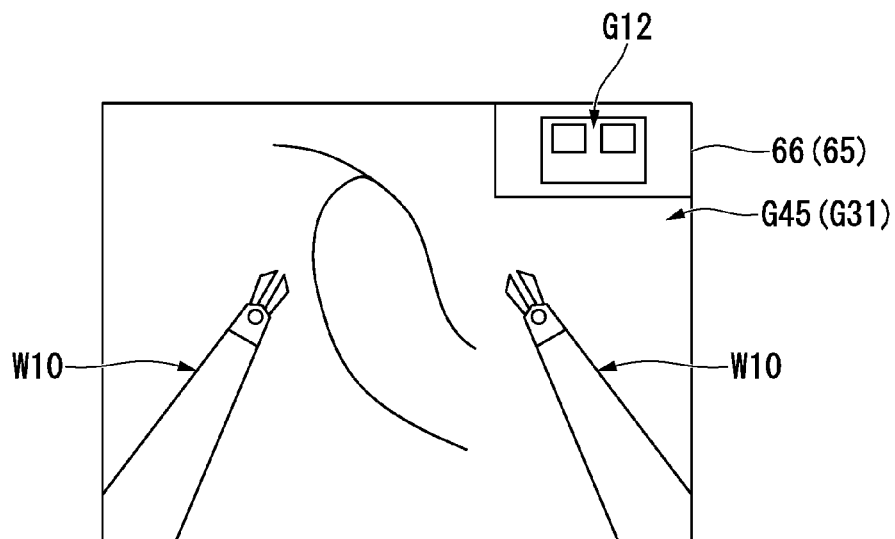


FIG. 13



SURGICAL ASSISTANT SYSTEM

This application is a continuation application based on PCT Patent Application No. PCT/JP2012/070581, filed Aug. 6, 2012, claiming priority based on U.S. Patent Provisional Application No. 61/515,203 filed on Aug. 4, 2011 and Japanese Patent Application No. 2012-043487 filed on Feb. 29, 2012, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION**1. Field of the Invention**

The present invention relates to a surgical assistant system.

2. Description of the Related Art

Conventionally, various surgical assistant systems have been developed in order to allow surgeons to easily perform surgery on patients.

For example, a surgical microscope device is disclosed in Japanese Unexamined Patent Application, First Publication No. 2002-14287. In the surgical microscope device of Japanese Unexamined Patent Application, First Publication No. 2002-14287, operation switches are disposed in a scope holder that holds an endoscope. These operation switches cause the usage state of the device to be detected via the scope holder, and cause an endoscopic image or an endoscope observation image to be switched and displayed on a microscope viewing field (display unit). According to the configuration of the surgical microscope device of Japanese Unexamined Patent Application, First Publication No. 2002-14287, it is possible to reduce the fatigue of the surgeon or to shorten the surgery time. In addition, it is possible for the surgeon to move the scope holder without moving the line of sight in the surgical microscope device of Japanese Unexamined Patent Application, First Publication No. 2002-14287.

In addition, generally, in a master-slave type surgical assistant system using an arm or a manipulator, the surgeon operating the arm of a master side sits in front of the console, and operates the arm while watching an immersive type monitor (display unit) displaying an image from the endoscope disposed in the console. According to this operation, the surgeon moves an arm of a slave side that treats the patient.

A plurality of arms or footswitches that are input devices are disposed in the console. The plurality of footswitches, for example, switches an operation mode of the system, and controls an output of a surgical energy device such as an electric scalpel mounted on the arm.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, a surgery support device includes an operation unit, an arm unit, an operation imaging unit, an endoscope, a mode control unit, a driving unit, a synthetic image creation unit, and a display unit. The operation unit gives an input. A treatment tool is mounted on the arm unit. The operation imaging unit acquires an operation image that is an image including the operation unit. The endoscope acquires an internal-body image including an image of an interior of a body of a patient. The mode control unit is configured to have a plurality of operation modes and to enable one of the plurality of operation modes to be set as a setting operation mode. The driving unit is configured to enable the arm unit to be operated based on the input given by the operation unit and the setting operation mode. The synthetic image creation unit synthesizes images

using at least the operation image to create a synthetic image based on the setting operation mode. The display unit displays the synthetic image.

According to a second aspect of the present invention, in the surgical assistant system according to the first aspect, the surgical assistant system may further include a mode switching unit configured to switch the operation mode. In the surgical assistant system, the operation mode may include a ready mode and a driving mode. In the ready mode, the arm unit may be in a state before being operatable by the operation unit, and the synthetic image creation unit creates the synthetic image including the operation image. In the driving mode, the driving unit may be capable of operating the arm unit based on the input given by the operation unit and the synthetic image creation unit creates the synthetic image including the operation image and the internal-body image. The mode switching unit may switch the operation mode set as the setting operation mode between the ready mode and the driving mode by transmitting a signal to the mode control unit.

According to a third aspect of the present invention, in the surgical assistant system according to the first aspect, the surgical assistant system may further include an arm imaging unit configured to acquire an arm image that is an image including the arm unit. The synthetic image creation unit may create the synthetic image by synthesizing images using the arm image.

According to a fourth aspect of the present invention, in the surgical assistant system according to the second aspect, the surgical assistant system may further include an arm imaging unit configured to acquire an arm image that is an image including the arm unit. The synthetic image creation unit may create the synthetic image by synthesizing images using the arm image.

According to a fifth aspect of the present invention, in the surgical assistant system according to the fourth aspect, the surgical assistant system may further include a positioning switching unit configured to switch the operation mode. In the surgical assistant system, the ready mode may include a standby mode and a positioning mode. In the standby mode, the arm unit may be in a standby state in which the arm unit waits in a state before being operatable by the operation unit, and the synthetic image creation unit creates the synthetic image including the operation image. In the positioning mode, a position of the arm unit may be capable of being adjusted, and the synthetic image creation unit creates the synthetic image including the operation image and the arm image. The positioning switching unit may switch the operation mode set as the setting operation mode between the standby mode and the positioning mode by transmitting a signal to the mode control unit.

According to a sixth aspect of the present invention, in the surgical assistant system according to the fourth aspect, the surgical assistant system may further include a standby exchange switching unit configured to switch the operation mode. In the surgical assistant system, the arm unit may be configured to enable the treatment tool to be detachable. The ready mode may include a standby mode and a standby surgical device exchange mode. In the standby mode, the arm unit may be in a standby state in which the arm unit waits in a state before being operatable by the operation unit, and the synthetic image creation unit may create the synthetic image including the operation image. In the standby surgical device exchange mode, the arm unit may be capable of being operated by the operation unit, and the synthetic image creation unit may create the synthetic image including the operation image, the internal-body image, and the arm image in a state

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in which the treatment tool can be exchanged. The standby exchange switching unit may switch the operation mode set as the setting operation mode between the standby mode and the standby surgical device exchange mode by transmitting a signal to the mode control unit.

According to a seventh aspect of the present invention, in the surgical assistant system according to the sixth aspect, the synthetic image creation unit may create the synthetic image in which the operation image and the internal-body image may be disposed at an edge of the arm image in the standby surgical device exchange mode.

According to an eighth aspect of the present invention, in the surgical assistant system according to the fourth aspect, the surgical assistant system may further include an emergency stop switching unit. In the surgical assistant system, the ready mode may include a standby mode and an emergency stop mode. In the standby mode, the arm unit may be in a standby state in which the arm unit waits in a state before being operable by the operation unit, and the synthetic image creation unit may create the synthetic image including the operation image. In the emergency stop mode, an operation of the arm unit may be forcibly stopped, and the synthetic image creation unit may create the synthetic image including the operation image, the internal-body image, and the arm image. The emergency stop switching unit may switch the operation mode set as the setting operation mode between the standby mode and the emergency stop mode by transmitting a signal to the mode control unit.

According to a ninth aspect of the present invention, in the surgical assistant system according to any one of the fourth to eighth aspects, the surgical assistant system may further include a driving exchange switching unit. In the surgical assistant system, the arm unit may enable the treatment tool to be detachable. The driving mode may include a driving normal surgical device mode and a driving surgical device exchange mode. In the driving normal surgical device mode, the synthetic image creation unit may create the synthetic image using the operation image and the internal-body image in a state in which the arm unit is operated by the operation unit. In the driving surgical device exchange mode, the arm unit may be capable of being operated by the operation unit, and the synthetic image creation unit may create the synthetic image including the operation image, the internal-body image, and the arm image in a state in which the treatment tool can be exchanged. The driving exchange switching unit may switch the operation mode set as the setting operation mode between the driving normal surgical device mode and the driving surgical device exchange mode by transmitting a signal to the mode control unit.

According to a tenth aspect of the present invention, in the surgical assistant system according to the ninth to eighth aspect, the synthetic image creation unit may create the synthetic image in which the operation image and the arm image are disposed at an edge of the internal-body image in the driving treatment exchange mode.

According to an eleventh aspect of the present invention, in the surgical assistant system according to any one of the fourth to eighth aspects, the surgical assistant system may further include an electric energy switching imaging unit configured to be a part of the operation imaging unit and a driving electric mode switching unit configured to switch the operation mode. In the surgical assistant system, the treatment tool may divide into a nonelectric type surgical device that does not use electric energy and an electric type surgical device that uses electric energy. The operation unit may have an electric energy switching unit switching whether or not the electric energy is supplied to the electric type surgical device

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as a part of the operation unit. The electric energy switching imaging unit may acquire an electric energy switching image that is an image including the electric energy switching unit. The electric energy switching imaging unit may be configured as a part of the operation imaging unit. The operation image may include the electric energy switching image. The driving mode may include a driving normal surgical device mode and a driving electricity treatment tool mode. In the driving normal surgical device mode, the synthetic image creation unit may create the synthetic image using the operation image and the internal-body image in a state in which the arm unit is operated by the operation unit. In the driving electricity treatment tool mode, the synthetic image creation unit may create the synthetic image including the internal-body image and the electric energy switching image. The driving electric mode switching unit may switch the operation mode set as the setting operation mode between the driving normal surgical device mode and the driving electricity treatment tool mode by transmitting a signal to the mode control unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view schematically illustrating a surgical assistant system in accordance with one embodiment of the present invention.

FIG. 2 is a block diagram illustrating the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 3 is a diagram illustrating operation modes of a mode control circuit of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 4 is a diagram illustrating a slave arm of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 5 is a perspective view illustrating a periphery of an operation desk of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 6 is a diagram illustrating a synthetic image displayed on a display in a standby mode of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 7 is a diagram illustrating a synthetic image displayed on a display in a standby surgical device exchange mode of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 8 is a diagram illustrating a synthetic image displayed on a display in an arm positioning mode of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 9 is a diagram illustrating a synthetic image displayed on a display in an emergency stop mode of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 10 is a diagram illustrating a synthetic image displayed on a display in a normal surgical device mode of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 11 is a diagram illustrating a synthetic image displayed on a display in a surgical energy device mode of the surgical assistant system in accordance with the embodiment of the present invention.

FIG. 12 is a diagram illustrating a synthetic image displayed on a display in a driving surgical device exchange mode of the surgical assistant system in accordance with the embodiment of the present invention.

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FIG. 13 is a diagram illustrating a synthetic image displayed on a display in an endoscope mode of the surgical assistant system in accordance with the embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, a surgical assistant system according to one embodiment of the present invention will be described with reference to FIGS. 1 to 13. Hereinafter, for example, a case in which the surgical assistant system is a master-slave type surgical assistant system will be described. The master-slave type surgical assistant system includes master arms 11A and 11B and slave arms 21A to 21D that will be described later. The master-slave type surgical assistant system is a device that remotely controls the slave arms 21A to 21D so as to follow operations of the master arms 11A and 11B to which the input is given by the surgeon.

As shown in FIGS. 1 and 2, the surgical assistant system 1 includes the master arms 11A and 11B, four slave arms 21A to 21D (arm unit), a slave control circuit 35 (driving unit) capable of driving the slave arms 21A to 21D, a master observation camera 40 acquiring an operation image that is an image including the master arms 11A and 11B, an endoscope 45 capable of observing the interior of a body of a patient P, a slave arm overhead camera 50 (arm imaging unit) acquiring an arm image that is an image including the slave arms 21A to 21D, a mode control circuit 55 (mode control unit) having a plurality of operation modes, an image processing circuit 60 (synthetic image creation unit) creating a synthetic image from the operation image and the arm image in response to the operation mode, and a display 65 (display unit) displaying the synthetic image.

In addition, since the master arms 11A and 11B have the same configuration, their symbols have common reference numerals. Since the slave arms 21A to 21D also have the same configuration except a part of the slave arm 21D, their symbols also have common reference numerals. For example, in the configuration of the slave arm 21A, letter "A" is added to the reference numeral. In the configuration of the slave arm 21B, letter "B" is added to the reference numeral.

First, a configuration of each operation mode of the mode control circuit 55 will be described.

As shown in FIG. 3, the operation mode is mainly divided into a ready mode M10 and a driving mode M20. In the ready mode M10, the slave arms 21A to 21D wait in a state before being operable by the master arms 11A and 11B. That is, the ready mode M10 is a mode in which the slave arms 21A to 21D are not operated by the slave control circuit 35 even when the master arms 11A and 11B are operated. On the other hand, the driving mode M20 is a mode in which the slave control circuit 35 causes some of the slave arms 21A to 21D to follow the input and operate based on the input given to the master arms 11A and 11B. Operations of the master arms 11A and 11B include operations (e.g., operations to open or close a pair of grasping pieces of the distal ends of the treatment tool) of the treatment tools mounted on the slave arms 21A to 21D via the grasping units 12A and 12B (see FIG. 5) disposed at distal ends of the master arms 11A and 11B.

The ready mode M10 includes a standby mode M11, a standby surgical device exchange mode M12, an arm positioning mode (positioning mode) M13, and an emergency stop mode M14. Meanwhile, the driving mode M20 includes a normal surgical device mode (driving normal surgical device mode) M21, a surgical energy device mode (driving electricity treatment tool mode) M22, a driving surgical device exchange mode M23, and an endoscope mode M24.

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Details of the modes will be described later, and switching between the modes may be performed as follows. In addition, any mode included in the driving mode M20 is switched to any mode included in the ready mode M10. Similarly, any mode included in the ready mode M10 is switched to any mode included in the driving mode M20.

Within the ready mode M10, the setting operation mode is arbitrarily switched between the standby mode M11, the standby surgical device exchange mode M12, the arm positioning mode M13, and the emergency stop mode M14 except for the case between the standby surgical device exchange mode M12 and the arm positioning mode M13. Within the driving mode M20, the setting operation mode is arbitrarily switched between the normal surgical device mode M21, the surgical energy device mode M22, the driving surgical device exchange mode M23, and the endoscope mode M24.

The description will continue with reference to FIGS. 1 and 2.

The patient P is observed and treated while being loaded on the surgical table 101. The slave arms 21A and 21D are disposed near the surgical table 101.

Although the slave arm 21A is configured to generally have multi-degree-of-freedom joints, hereinafter, elements of some of the slave arms 21A to 21D are focused on and described for simplicity of description. That is, when each of the slave arms 21A to 21D has one joint, a case in which the slave arm 21A has a proximal end side support shaft (proximal end side support) 22A, a distal end side support shaft (distal end support) 23A, and a joint unit 24A as shown in FIG. 4 will be basically described. The proximal end side support shaft 22A is fixed to a housing case of the slave control circuit 35. The joint unit 24A connects the proximal end side support shaft 22A and the distal end side support shaft 23A.

A holding unit 26A that is slidable in a direction orthogonal to the longitudinal direction of the distal end side support shaft 23A is disposed at the distal end portion of the distal end side support shaft 23A. An insertion hole 27A is formed in the holding unit 26A. A pair of arm side electrodes 28A are exposed and disposed within the insertion hole 27A. The insertion hole 27A is configured to enable the treatment tool such as a grasping forceps W10 or a high-frequency electric knife W20 that will be described later to be detachable.

The treatment tool is divided into a nonelectric type surgical device such as the grasping forceps W10 that does not use the electric energy and an electric type surgical device such as the high-frequency electric knife W20 that does use electric energy. An electric resistor (first identification unit) W11 is disposed in the grasping forceps W10 while a pair of treatment tool side electrodes is exposed. A pair of grasping pieces W12 is disposed at the distal end side of the grasping forceps W10.

An electric resistor (second identification unit) W21 having a different resistance value (electrical property) from the electric resistor W11 is disposed in the high-frequency electric knife W20 while the pair of treatment tool side electrodes are exposed. A knife W22 is disposed at the distal end portion of the high-frequency electric knife W20.

When the proximal end portion of the grasping forceps W10 is inserted into the insertion hole 27A, the arm side electrode 28A of the holding unit 26A and the treatment tool side electrode of the grasping forceps W10 are electrically connected to each other. In this case, a constant voltage is applied between the arm side electrodes 28A to measure the resistance value of the electric resistor W11 by virtue of the identification unit 102. Further, the pair of grasping pieces W12 are moved toward each other or spaced apart from each

other by operating the slave arm 21A using a mechanism and a power unit that is built in the slave arm 21A but not shown. A so-called opening and closing operation for the pair of grasping pieces W12 is possible. The power unit mentioned above, for example, may use a servo motor.

When the proximal end portion of the high-frequency electric knife W20 is inserted into the insertion hole 27A, the arm side electrode 28A of the holding unit 26A and the treatment tool side electrode of the high-frequency electric knife W20 are electrically connected to each other. In this case, a resistance value of the electric resistor W21 is measured by the identification unit 102. Further, a high-frequency current (electric energy) may be supplied to the high-frequency electric knife W20 from the slave arm 21A side by an electrode that is not shown.

In this way, it is possible for the identification unit 102 to detect which of the electric resistor W11 and the electric resistor W21 the treatment tool mounted on the holding unit 26A has by measuring the resistance value. The identification unit 102 transmits a signal indicating the kind of the detected treatment tool to the mode control circuit 55.

The joint unit 24A has an electromagnetic clutch, a power unit, and so forth that are not shown. The power unit, for example, may include a motor (a servo motor) equipped with the servomechanism having an incremental encoder or a decelerator. By transmitting the control signal to the joint unit 24A and supplying electric energy to the joint unit 24A from the slave control circuit 35, it is possible for the joint unit 24A to adjust an arrangement angle θA formed between the proximal end side support shaft 22A and the distal end side support shaft 23A to a desired value.

For example, the slave control circuit 35 is configured to have a CPU or a memory in which a control program is stored. In addition, by detecting the arrangement angle θA when the helper (assistant doctor or nurse) and the like that will be described later has adjusted the position of the distal end side support shaft 23A, the slave control circuit 35 can store the adjusted arrangement angle θA in the memory as an initial position of the slave arm 21A.

In addition, the slave arm 21D on which the endoscope 45 is detachably mounted as described above has the same configuration (not shown) as the slave arm 21A except for the holding unit 26A. The holding unit of the slave arm 21D is configured to allow the endoscope 45 to be mounted.

The slave control circuit 35 also controls the power unit that is built in the slave arm 21A. The slave control circuit 35 selects all or some of the slave arms 21A to 21D by designating a slave changeover switch 106 that will be described later. Further, the slave control circuit 35 can follow the input given to the master arms 11A and 11B and be driven based on the setting operation mode set by the mode control circuit 55.

A surgical device exchange switch (standby exchange switching unit and driving exchange switching unit) 36, a positioning switch (positioning switching unit) 37, and an emergency stop switch (emergency stop switching unit) 38 are disposed in the slave control circuit 35.

As shown in FIG. 2, the surgical device exchange switch 36, the positioning switch 37, and the emergency stop switch 38 are connected to the mode control circuit 55.

A signal is transmitted to the mode control circuit 55 by operating the surgical device exchange switch 36.

The mode control circuit 55 switches the setting operation mode to the standby surgical device exchange mode M12 based on the signal while the current setting operation mode is any mode within the ready mode M10 based on the signal. In addition, when the current setting operation mode is any

mode within the driving mode M20, the mode control circuit switches the setting operation mode to the driving surgical device exchange mode M23.

A signal is transmitted to the mode control circuit 55 by operating the positioning switch 37, and the setting operation mode is then switched to the arm positioning mode M13. A signal is transmitted to the mode control circuit 55 by operating the emergency stop switch 38, and the setting operation mode is then switched to the emergency stop mode M14.

The slave control circuit 35 can position the grasping forceps W10 mounted on the holding unit 26A with respect to the patient P loaded on the surgical table 101 by adjusting the arrangement angle θA formed by the joint unit 24A of the slave arm 21A.

As shown in FIG. 1, the viewing range 51 of the slave arm overhead camera 50 mentioned above is set such that an entire image of the slave arms 21A to 21D driven in this way can be acquired. The slave arm overhead camera 50 may be disposed to look down upon the entire surgical room as well as the slave arms 21A to 21D.

Although the master arm 11A is configured to be smaller than the slave arm 21A, the master arm 11A basically has a similar configuration to the slave arm 21A. That is, the master arm 11A has a configuration in which a sensor (such as an incremental encoder) detecting the arrangement angle formed by the support shaft is disposed between the pair of support shafts.

As shown in FIG. 5, the viewing range 41 of the master observation camera 40 mentioned above is set such that the images of the master arms 11A and 11B can be acquired.

The slave changeover switch 106 for switching the slave arms 21A to 21D operated by the master arms 11A and 11B, an endoscope mode switching footswitch 105, a mode switching footswitch 107 (mode switching unit and driving electric mode switching unit), a surgical energy device activation footswitch 108 (electric energy switching unit), and the display 65 are disposed near the master arms 11A and 11B. In addition, the operation unit is configured to include the master arms 11A and 11B, the endoscope mode switching footswitch 105, the mode switching footswitch 107, and the surgical energy device activation footswitch 108.

As shown in FIG. 2, the master arms 11A and 11B, the slave changeover switch 106, the mode switching footswitch 107, and the surgical energy device activation footswitch 108 are connected to an input processing circuit 109. The input processing circuit 109 is used to collect wires for signals to be transmitted from the master arms 11A and 11B sides to the slave arms 21A to 21D sides. The input processing circuit 109 has a known configuration. An angle detected by the sensors of the master arms 11A and 11B and signals transmitted from the slave changeover switch 106 and the surgical energy device activation footswitch 108 are transmitted to the slave control circuit 35 via the input processing circuit 109. On the other hand, signals transmitted from the endoscope mode switching footswitch 105 and the mode switching footswitch 107 are transmitted to the mode control circuit 55 via the input processing circuit 109.

The slave changeover switch 106 can set the slave arm to be operated by the slave control circuit 35 among the slave arms 21A to 21D.

The setting operation mode is in the standby mode M11 right after a power is supplied. The signal is transmitted from the mode switching footswitch 107 to the mode control circuit 55 by operating the mode switching footswitch 107. When the signal is transmitted, the operation mode set to the setting operation mode is switched to the standby mode M11, the normal surgical device mode M21, or the surgical energy

device mode M22. When the endoscope mode switching footswitch 105 is operated, the operation mode set to the setting operation mode is switched to the endoscope mode M24. It is possible to adjust the amount of the high-frequency current to be supplied by operating the surgical energy device activation footswitch 108 to switch whether or not the high-frequency current is supplied to the high-frequency electric knife W20 mounted on the slave arm selected by the slave changeover switch 106 among the holding units 26A to 26C of the respective slave arms 21A to 21C.

As the display 65, an immersive type monitor in which a display surface 66 is more recessed than an outer surface of the main body 67 is used. A liquid crystal panel or the like may be properly used for the display surface 66. The display 65 displays an image on the display surface 66 which is converted from the signal transmitted from the image processing circuit 60 which will be described later by a circuit (not shown).

In order to acquire an image including the mode switching footswitch 107 and the endoscope mode switching footswitch 105, a mode switching footswitch camera 111 is disposed above the mode switching footswitch 107 and the endoscope mode switching footswitch 105. Similarly, in order to acquire a surgical energy device activation footswitch image (electric energy switching image) that is an image including the surgical energy device activation footswitch 108, a surgical energy device activation footswitch camera 112 (electric energy switching imaging unit) is disposed above the surgical energy device activation footswitch 108. In addition, the operation imaging unit is configured to include the master observation camera 40 and the surgical energy device activation footswitch camera 112.

The master arms 11A and 11B, the slave changeover switch 106, and the endoscope mode switching footswitch 105 are disposed on the top board 116 of the operation desk 115. The mode switching footswitch camera 111 and surgical energy device activation footswitch camera 112 are attached to a bottom part of the top board 116. The master observation camera 40 is attached to a support (not shown) of the operation desk 115.

The endoscope 45 may include an endoscope that is properly selected from endoscopes having a known configuration with a long insertion unit 46 shown in FIG. 1. An illumination unit or an imaging unit (not shown) is disposed at the distal end of the insertion unit 46. It is possible to acquire the internal-body image that is an image of the interior of the body of the patient P by inserting the insertion unit 46 into the body of the patient P. In this case, the endoscope 45 is mounted on the slave arm 21D.

As shown in FIG. 2, the master observation camera 40, the endoscope 45, the slave arm overhead camera 50, the mode switching footswitch camera 111, and the surgical energy device activation footswitch camera 112 are connected to the image processing circuit 60, and transmit the respective acquired images to the image processing circuit 60.

The image processing circuit 60 may include an image processing circuit having a known configuration. The image processing circuit 60 creates a synthetic image based on the setting operation mode set by the mode control circuit 55, converts information on the created synthetic image to a signal and transmits the signal to the display 65. The synthetic image is created such that the images transmitted from the master observation camera 40 and the like are arranged or overlapped.

In addition, in the image displayed on the display surface 66, although the positions of the endoscope 45 and the treatment tool of the slave arms 21A to 21D and the position of the

treatment tool of the internal-body image are properly corrected in the drawings, this is intended to simplify the description.

Next, details of each mode of the mode control circuit 55 will be described. First, each mode within the ready mode M10 will be described. An operation image G11 is displayed on the display surface 66 in any of the standby mode M11, the standby surgical device exchange mode M12, the arm positioning mode M13, and the emergency stop mode M14 within the ready mode M10.

When the setting operation mode of the mode control circuit 55 is the standby mode M11, the slave arms 21A to 21D are in a standby state before the slave arms are capable of being operated by the operation of the operation unit. In particular, the slave control circuit 35 sets the arrangement angles θA to θC formed by the joint units 24A to 24C to the desired angles to fix the slave arms 21A to 21C based on the setting operation mode. Further, as shown in FIG. 6, the image processing circuit 60 creates a synthetic image G10 in which the operation image G11 including the master arms 11A and 11B acquired by the master observation camera 40 and a mode switching footswitch image G12 that is an image including the mode switching footswitch 107 and the endoscope mode switching footswitch 105 are arranged side by side based on the setting operation mode. The image processing circuit 60 converts the synthetic image G10 to a signal and transmits the signal. The transmitted signal is converted by a circuit (not shown) within the display 65, and the synthetic image G10 is displayed on the display surface 66.

When the surgeon grasps the master arms 11A and 11B with his or her hands, the hands Q1 are displayed in the operation image G11. In addition, when the surgeon steps on the mode switching footswitch 107 or the endoscope mode switching footswitch 105 with his or her foot, the foot Q2 is displayed in the mode switching footswitch image G12.

When the setting operation mode is the standby surgical device exchange mode M12, the slave control circuit 35 sets the arrangement angles θA to θC formed by the joint units 24A to 24C to desired angles and fixes the slave arms 21A to 21C. Further, as shown in FIG. 7, the image processing circuit 60 creates a synthetic image G15 in which the operation image G11 and an internal-body image G17 acquired by the endoscope 45 are disposed at an edge of an arm image G16 including the slave arms 21A to 21D acquired by the slave arm overhead camera 50. The created synthetic image G15 is displayed on the display surface 66. In addition, only the distal end sides of the slave arms 21A to 21D are schematically illustrated in FIGS. 7, 8, 9, and 12.

When the setting operation mode is the arm positioning mode M13, the slave control circuit 35 causes an exert force to the joint units 24A to 24C so as to support the proximal end side support shafts 22A to 22C against gravity. Therefore, as the helper or the like directly and manually moves to the slave arms 21A to 21C, the positions of the leading end side support shafts 23A to 23C are capable of being adjusted. That is, holding force weaker than that for maintaining the arrangement angles θA to θC is exerted by the joint units 24A to 24C. Further, as shown in FIG. 8, the image processing circuit 60 creates a synthetic image G20 in which the operation image G11 and the internal-body image G17 are disposed at an edge of the arm image G16. The created synthetic image G20 is displayed on the display surface 66.

When the setting operation mode is the emergency stop mode M14, the slave control circuit 35 performs control such that a movement of the slave arms 21A to 21D to be forcibly stopped. In particular, supplying the electric energy to the joint unit 24A and transmitting the control signal are stopped.

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Further, as shown in FIG. 9, the image processing circuit 60 creates a synthetic image G25 in which the operation image G11 and the mode switching footswitch image G12 are disposed at an edge of the image in which the internal-body image G17 and the arm image G16 are disposed side by side. The created synthetic image G25 is displayed on the display surface 66.

Next, each mode within the driving mode M20 will be described. The slave control circuit 35 causes the selected slave arm among the slave arms 21A to 21D to be operated based on the input given to the master arms 11A and 11B in any of the normal surgical device mode M21, the surgical energy device mode M22, the driving surgical device exchange mode M23, and the endoscope mode M24 within the driving mode M20. The internal-body image is displayed on the display surface 66.

When the setting operation mode is the normal surgical device mode M21, as shown in FIG. 10, the image processing circuit 60 creates a synthetic image G30 in which the operation image G11 and the mode switching footswitch image G12 are disposed at an edge of an internal-body image G31. The created synthetic image G30 is displayed on the display surface 66.

When the setting operation mode is the surgical energy device mode M22, as shown in FIG. 11, the image processing circuit 60 creates a synthetic image G35 in which the operation image G11, the mode switching footswitch image G12, and an surgical energy device activation footswitch image G36 acquired by the surgical energy device activation footswitch camera 112 are disposed at an edge of the internal-body image G31. The created synthetic image G35 is displayed on the display surface 66.

When the setting operation mode is the driving surgical device exchange mode M23, as shown in FIG. 12, the image processing circuit 60 creates a synthetic image G40 in which the arm image G16 and the mode switching footswitch image G12 are disposed at an edge of the internal-body image G31. The created synthetic image G40 is displayed on the display surface 66.

When the setting operation mode is the endoscope mode M24, as shown in FIG. 13, the image processing circuit 60 creates a synthetic image G45 in which the mode switching footswitch image G12 is disposed at an edge of the internal-body image G31. The created synthetic image G45 is displayed on the display surface 66.

In addition, when the surgical assistant system 1 is started up, the setting operation mode is set to the standby mode M11.

Next, operations of the surgical assistant system 1 configured as described above will be described.

Since the setting operation mode is in the standby mode M11 when the surgical assistant system 1 is started up, the slave arms 21A to 21C are fixed by the slave control circuit 35. The synthetic image G10 created by the image processing circuit 60 and shown in FIG. 6 is displayed on the display surface 66 of the display 65.

A helper A lays the patient P on the surgical table 101, and performs appropriate treatment such as sterilization or anesthesia.

A surgeon Q sits on a chair (not shown) disposed in front of the operation desk 115 and grasps the master arms 11A and 11B with his or her right and left hands, respectively. His or her face is toward the display surface 66.

Since the operation image G11 and the mode switching footswitch image G12 are displayed on the display surface 66, it is possible for the surgeon Q to confirm the state in which the master arms 11A and 11B, the endoscope mode

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switching footswitch 105, and the mode switching footswitch 107 are being operated on the display surface 66 even while the surgeon is carefully watching the display surface 66.

When the helper A presses the surgical device exchange switch 36 to change the setting operation mode from the standby mode M11 to the standby surgical device exchange mode M12, the synthetic image G15 including the image of the slave arms 21A to 21D shown in FIG. 7 is displayed on the display surface 66. For example, the helper A mounts the grasping forceps W10 on each of the holding units 26A to 26C of the slave arms 21A to 21C in response to contents of the procedure in accordance with the instruction of the surgeon Q. The surgeon Q confirms that the treatment tools are mounted on the slave arms 21A to 21C by virtue of the display surface 66. In this case, the identification unit 102 confirms the kind of the treatment tool attached to the slave arm 21C.

When the treatment tool is mounted to finish the treatment tool exchange, the setting operation mode is switched to the standby mode M11. For example, it is preferable that the switching be automatically performed when it is detected that the treatment tool is mounted by having a detection unit that detects that the treatment tool is mounted on the treatment tool device. However, the switching may be performed by disposing a switch such as the surgical device exchange switch 36 to be switched to the standby mode M11 within the viewing range 41 and pressing the switch.

When the helper A presses the positioning switch 37 to switch the setting operation mode to the arm positioning mode M13, the synthetic image G20 including the slave arms 21A to 21D shown in FIG. 8 is displayed on the display surface 66.

The helper A moves the distal end side support shaft 23A of the slave arm 21A with his or her own power, and introduces the treatment tool from the Trocar (not shown) inserted into the patient P or the insertion unit 46 of the endoscope 45 into the body. Since the image of the helper A moving the distal end side support shaft 23A is displayed on the display surface 66, the surgeon Q confirms that positioning of the slave arm 21A is being properly performed.

When the positioning of the arm is finished, the setting operation mode is switched to the standby mode M11. For example, it is preferable that the switching be automatically performed when the switch disposed in the slave arms 21A to 21D is pressed to perform the positioning and the switch is taken off after the positioning. However, a switch such as the positioning switch 37 to be switched to the standby mode M11 may be disposed within the viewing range 41 and the switch may be pressed to perform the switching as described above.

When some kind of urgent problem occurs with the surgical assistant system 1, the surgeon Q or the helper A presses the emergency stop switch 38 to switch to the emergency stop mode M14. This enables the electric energy supplied to the joint units 24A to 24D to be stopped. Further, the synthetic image G25 including the internal-body image G17 and the arm image G16 shown in FIG. 9 is displayed on the display surface 66.

When it is time to actually administer treatment to the patient P using the treatment tool, the surgeon Q presses the mode switching footswitch 107 with his or her foot Q2. When the mode control circuit 55 does not receive the signal indicating that the surgical energy device is mounted on the slave arms 21A to 21C, the mode control circuit switches the setting operation mode to the normal surgical device mode M21. The synthetic image G30 in which the operation image G11 and the mode switching footswitch image G12 are disposed at an edge of the internal-body image G31 shown in FIG. 10 is

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then displayed on the display surface 66. The internal-body image G31 is an image acquired by an imaging unit of the endoscope 45.

The slave changeover switch 106 is operated to select the slave arms 21A and 21B that will follow the master arms 11A and 11B among the slave arms 21A to 21D. By operating the master arms 11A and 11B, proper treatment is performed on the patient P using the grasping forceps W10. Meanwhile, the slave arms 21C and 21D are stopped.

Since the synthetic image G30 including the internal-body image G31 is displayed on the display surface 66, it is possible for the surgeon Q to perform the treatment while confirming the state of the interior of the body of the patient P by virtue of the synthetic image 30.

When the surgeon Q determines to perform the treatment using the high-frequency electric knife W20, the surgeon instructs the helper A to press the surgical device exchange switch 36 and switch the setting operation mode from the normal surgical device mode M21 to the driving surgical device exchange mode M23. The synthetic image G40 in which the arm image G16 and the mode switching footswitch image G12 are disposed at an edge of the internal-body image G31 shown in FIG. 12 is then displayed on the display surface 66.

The helper A removes the grasping forceps W10 from the slave arm 21C that is currently stopped, and mounts the high-frequency electric knife W20 on the holding unit 26C of the slave arm 21C. The surgeon Q confirms that the proper treatment tool is mounted on the slave arm 21C by virtue of the image of the slave arm 21C displayed on the display surface 66.

When the identification unit 102 detects that the high-frequency electric knife W20 is mounted on the slave arm 21C, the slave changeover switch 106 may be operated to switch the setting operation mode to the surgical energy device mode M22. In particular, when it is detected that the high-frequency electric knife W20 is mounted on the slave arm that may be operated by following the master arms 11A and 11B, the slave changeover switch 106 may be operated to switch the setting operation mode to the surgical energy device mode M22.

The surgeon Q operates the slave changeover switch 106 to switch the slave arm capable of being operated by following the master arm 11B from the slave arm 21B to the slave arm 21C. In this case, since it is detected that the high-frequency electric knife 21C is mounted on the slave arm 21C, the setting operation mode is switched to the surgical energy device mode M22. The synthetic image G35 in which the operation image G11, the mode switching footswitch image G12, and the surgical energy device activation footswitch image G36 are disposed at an edge of the internal-body image G31 shown in FIG. 11 is then displayed on the display surface 66.

The surgeon Q operates the master arm 11B to dispose the high-frequency electric knife W20 near the patient P.

The surgeon operates the surgical energy device activation footswitch 108 to supply the high-frequency current to the high-frequency electric knife W20 mounted on the slave arm 21C and make an incision in the affected part while confirming the internal-body image G31 and the surgical energy device activation footswitch image G36 within the synthetic image G35 displayed on the display surface 66.

The surgeon Q operates the endoscope mode switching footswitch 105 when trying to operate the endoscope 45 mounted on the slave arm 21D. The setting operation mode is then switched to the endoscope mode M24. The synthetic image G45 in which the mode switching footswitch image

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G12 is disposed at an edge of the internal-body image G31 shown in FIG. 13 is displayed on the display surface 66.

In this way, the surgeon Q administers treatment to the patient P by operating the master arms 11A and 11B, the slave changeover switch 106, the mode switching footswitch 107, and the surgical energy device activation footswitch 108 while always watching the display surface 66 and giving an instruction to the helper A.

As described above, in the surgical assistant system 1 according to the present embodiment, the operation image G11 is displayed on the display 65 in any mode within the ready mode M10. Therefore, even when the surgeon Q is carefully watching the display 65, it is possible to recognize the positions of the master arms 11A and 11B by virtue of the operation image G11 displayed on the display 65. The surgeon Q can thus suppress the time taken to find the master arms 11A and 11B.

In the standby mode M11, since the operation image G11 and the mode switching footswitch image G12 are displayed together, it is possible to suppress the time taken for the surgeon Q to find the master arms 11A and 11B, the endoscope mode switching footswitch 105, and the mode switching footswitch 107 while preventing the master arms 11A and 11B, the endoscope mode switching footswitch 105, and the mode switching footswitch 107 from being operated by mistake.

When the positioning switch 37 is operated to switch the setting operation mode to the arm positioning mode M13, it is possible for the surgeon Q to quickly respond to the emergency occurrence by confirming the arm image G16 displayed on the display 65.

By operating the surgical device exchange switch 36, the setting operation mode is switched to the standby surgical device exchange mode M12. By displaying the arm image G16 including the slave arms 21A to 21D on the display 65, it is possible for the surgeon Q carefully watching the display 65 to confirm the treatment tool to be attached to or detached from the slave arms 21A to 21D by the helper A. In addition, by confirming the arm image G16, it is possible for the surgeon Q to quickly respond to the emergency occurrence.

In the standby surgical device exchange mode M12, the image processing circuit 60 creates the synthetic image G15 in which the operation image G11 and the internal-body image G17 are disposed at an edge of the arm image G16. Therefore, even while the surgeon Q carefully watching the display 65 mainly observes the arm image G16, it is possible for the surgeon to confirm the state in which the surgeon is grasping the master arms 11A and 11B or the internal-body image G17 acquired by the endoscope 45.

By operating the emergency stop switch 38, the setting operation mode is switched to the emergency stop mode M14. In the emergency stop mode M14, the electric energy supplied to the joint units 24A to 24D is stopped. The synthetic image G25 including the internal-body image G17, the arm image G16, and the mode switching footswitch image G12 is displayed on the display surface 66. The surgeon Q can confirm the safety of the patient P and the surgical assistant system 1 by confirming the internal-body image of the patient P and the situation around the slave arms 21A to 21D and can also quickly respond to the emergency occurrence.

By operating the surgical device exchange switch 36, the setting operation mode is switched to the driving surgical device exchange mode M23. Since not only the internal-body image G31 but also the arm image G16 including the slave arms 21A to 21D is displayed on the display 65, the surgeon Q carefully watching the display 65 can confirm the treatment

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tool (treatment tool attached to or detached from the slave arms **21A** to **21D** by the helper **A**).

In the driving surgical device exchange mode **M23**, the synthetic image **G40** in which the arm image **G16** and the mode switching footswitch image **G12** are disposed at an edge of the internal-body image **G31** is displayed on the display **65**. The surgeon **Q** can confirm the treatment tool that is attached to or detached from the slave arms **21A** to **21C** by virtue of the arm image **G16** even while mainly observing the internal-body image **G31** and operating the master arms **11A** and **11B** to administer treatment.

By operating the mode switching footswitch **107** when the high-frequency electric knife **W20** is mounted on the holding units **26A** to **26C**, the setting operation mode is switched to the surgical energy device mode **M22**.

In the surgical energy device mode **M22**, since the surgical energy device activation footswitch image **G36** is displayed at an edge of the internal-body image **G31**, the surgeon **Q** can confirm the surgical energy device activation footswitch image **G36** even while mainly observing the internal-body image **G31**. Further, the mode switching footswitch image **G12** and the surgical energy device activation footswitch image **G36** are displayed on the display **65**. Therefore, it is possible to prevent the surgeon **Q** from hesitating to select the desired switch among a plurality of the footswitches **107** and **108** or operating the footswitches **107** and **108** by mistake.

The embodiment of the present invention has been described with reference to drawings. However, the particular configuration is not limited to the embodiment, and changes in configuration not departing from the scope of the present invention are also included. For example, in the present embodiment, the number of master arms and slave arms may be properly set in response to the specification of the surgical assistant system. The operation unit is the master arms **11A** and **11B**. However, the operation unit may be an operation unit having a different configuration such as a so-called joystick.

In the present embodiment, the image processing circuit **60** creates the synthetic image **G15** in which the operation image **G11** and the internal-body image **G17** are disposed at an edge of the arm image **G16** in the standby surgical device exchange mode **M12**. However, the synthetic image created in the standby surgical device exchange mode **M12** is not limited thereto. For example, the synthetic image may be one in which only the operation image **G11** is disposed at the edge of the arm image **G16**. The synthetic image may be configured such that the arm image **G16**, the operation image **G11**, and the internal-body image **G17** having the same size as each other are arranged.

In the present embodiment, the image processing circuit **60** creates the synthetic image **G30** in which the operation image **G11** and the mode switching footswitch image **G12** are disposed at the edge of the internal-body image **G31** in the normal surgical device mode **M21**. However, the image processing circuit **60** may create and display the synthetic image using only the internal-body image **31**.

In the present embodiment, the image processing circuit **60** creates the synthetic image **G40** in which the arm image **G16** and the mode switching footswitch image **G12** are disposed at the edge of the internal-body image **G31** in the driving surgical device exchange mode **M23**. However, the synthetic image in which the internal-body image **G31** and the arm image **16** are arranged may be created.

In addition, the operation image **G11** may be set to be displayed on the display surface **66** in each mode within the driving mode **M20** as well as the ready mode **M10**.

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The surgical energy device activation footswitch image **G36** may also be set to be displayed even in the driving surgical device exchange mode **M23** or the endoscope mode **M24**.

In the present embodiment, the first and second identification units are configured to have electric resistors of which the resistance values are different from each other and to enable an identification unit to detect the resistance values of the electric resistors. However, the first identification, the second identification, and the identification unit are not limited thereto, and various configurations that will be described below may be employed.

For example, the connection state regarding whether or not the electric resistor having a constant resistance value is connected between treatment tool side electrodes of each pair with respect to the entire **N** pairs of the treatment tool side electrodes is changed for each kind of the treatment tool while the **N** pairs of the treatment tool side electrodes are exposed and disposed in the treatment tool. The identification unit identifies ON when the treatment tool side electrodes of each pair are connected via the electric resistor and identifies OFF when the treatment tool side electrodes of each pair are not connected via the electric resistor. The kind of the treatment tool is identified in the manner of binary system by combining the **N** ONs or OFFs.

N positions in which convex portions are disposed on the outer surface of the treatment tool are arranged. All of the **N** positions are combined in association with whether or not the convex portions are disposed in each of the setting positions, that is, the outer shape of the treatment tool is changed for each kind of the treatment tool. The kind of the treatment tool is identified by causing the **N** switches disposed in the identification unit side to detect whether or not the convex portions are disposed in the respective setting positions.

In addition, as a different configuration of the identification unit, identification information such as a bar code is disposed in the treatment tool and information included in the identification information is changed for each kind of the treatment tool. The kind of the treatment tool is identified by the identification unit detecting and reading the identification information.

In the present embodiment, the setting operation mode is configured to be arbitrarily switched among the standby mode **M11**, the standby surgical device exchange mode **M12**, the arm positioning mode **M13**, and the emergency stop mode **M14**, and among the normal surgical device mode **M21**, the surgical energy device mode **M22**, the driving surgical device exchange mode **M23**, and the endoscope mode **M24** except between the standby surgical device exchange mode **M12** and the arm positioning mode **M13**. However, the setting operation mode may be switched only between the standby mode **M11** and the standby surgical device exchange mode **M12**, between the standby mode **M11** and the arm positioning mode **M13**, and between the standby mode **M11** and the emergency stop mode **M14** within the ready mode **M10**. This also applies to the driving mode **M20** in the same way.

In the ready mode **M10** and the driving mode **M20**, all of the modes mentioned above are not limited to some cases, and a proper mode is properly set by the device configuration. For example, when it is difficult to exchange the treatment tool in the slave arms **21A** to **21C** (e.g., an integrated structure of the slave arm and the treatment tool), the treatment tool exchange mode may be omitted in the ready mode **M10** and the driving mode **M20**. In addition, when the surgical energy device is not used, the surgical energy device mode **M22** may be omitted in the driving mode **M20**. When the standby mode **M11** is included in the ready mode **M10**, the other modes may be

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properly set. The modes other than the normal surgical device mode M21 may be properly set even in the driving mode M20.

In addition, the configuration of the operation unit is not limited to the master arm, and may employ the joystick. In addition, when the surgical energy device is not used in the configuration of the surgical assistant system as described above, the surgical energy device activation footswitch or the like may be omitted. The configuration of the operation unit is properly set by the configuration of the surgical assistant system, the number of the modes to be set, and so forth. In a similar way, the operation imaging unit is properly set by the configuration of the surgical assistant system, the number of the modes to be set, and so forth.

The nonelectric type surgical device may include the treatment tool such as a needle holder or scissors that is properly selected in addition to the grasping forceps W10. On the other hand, the electric type surgical device may include an ultrasonic surgical device or a snare in addition to the high-frequency electric knife W20.

In the present embodiment, the surgical device exchange switch 36, the positioning switch 37, and the emergency stop switch 38 are disposed in the base of the slave arm as shown in FIG. 4. However, these switches 36, 37, and 38 may be disposed in positions within the viewing range 41 of the master observation camera 40. In addition, these switches 36, 37, and 38 may be disposed in both of the base and positions within the viewing range 41.

In the present embodiment, the slave arms are switched by operating the slave changeover switch 106. However, the slave arms may be switched by operating the mode switching footswitch 107. For example, when the mode switching footswitch 107 is pressed for a short time in the ready mode M10, the slave arms 21A and 21B are allocated to the respective master arms 11A and 11B, and are transitioned to the driving mode M20 and can thus be operated. Next, when the mode switching footswitch 107 is pressed for a short time, the slave arm 21C is allocated to the master arm 11A, the slave arm 21A is stopped for the occasion, and the slave arm 21C is thus capable of being operated. Which slave arms 21A to 21D are allocated to the master arms 11A and 11B is set beforehand. When the mode is transitioned from the driving mode M20 to the ready mode M10, the mode switching footswitch 107 is pressed for a long time. In this case, since a timer is built in the mode control circuit 55 and the time taken for which the signal is continuously transmitted from the mode switching footswitch 107 is measured, it is recognized, namely, that the mode switching footswitch 107 is pressed for a long time or a short time.

While preferred embodiments of the present invention have been described and illustrated above, it should be understood that these are exemplary of the present invention and are not to be considered as limiting. Additions, omissions, substitutions, and other modifications can be made without departing from the spirit or scope of the present invention. Accordingly, the present invention is not to be considered as being limited by the foregoing description, and is only limited by the scope of the appended claims.

What is claimed is:

1. A surgical assistant system comprising:
an operation unit configured to give an input;
an arm unit on which a treatment tool is mounted;
an operation imaging unit configured to acquire an operation image that is an image including the operation unit;
an endoscope configured to acquire an internal-body image including an image of an interior of a body of a patient;

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a mode control unit having a plurality of operation modes and configured to enable one of the plurality of operation modes to be set as a setting operation mode;

a driving unit configured to enable the arm unit to be operated based on the input given by the operation unit and the setting operation mode;

a synthetic image creation unit configured to synthesize images using at least the operation image to create a synthetic image based on the setting operation mode; and

a display unit configured to display the synthetic image.

2. The surgical assistant system according to claim 1, further comprising:

a mode switching unit configured to switch the operation modes,

wherein the operation modes include:

a ready mode in which the arm unit is in a state before being operable by the operation unit and the synthetic image creation unit creates the synthetic image including the operation image; and

a driving mode in which the driving unit is capable of operating the arm unit based on the input given by the operation unit and the synthetic image creation unit creates the synthetic image including the operation image and the internal-body image, and

the mode switching unit switches the operation mode set as the setting operation mode between the ready mode and the driving mode by transmitting a signal to the mode control unit.

3. The surgical assistant system according to claim 2, further comprising:

an arm imaging unit configured to acquire an arm image that is an image including the arm unit,

wherein the synthetic image creation unit creates the synthetic image by synthesizing images using the arm image.

4. The surgical assistant system according to claim 3, further comprising:

a positioning switching unit configured to switch the operation modes,

wherein the ready mode includes:

a standby mode in which the arm unit is in a standby state in which the arm unit waits in a state before being operable by the operation unit and the synthetic image creation unit creates the synthetic image including the operation image; and

a positioning mode in which a position of the arm unit is capable of being adjusted and the synthetic image creation unit creates the synthetic image including the operation image and the arm image, and

the positioning switching unit switches the operation mode set as the setting operation mode between the standby mode and the positioning mode by transmitting a signal to the mode control unit.

5. The surgical assistant system according to claim 3, further comprising:

a standby exchange switching unit configured to switch the operation modes,

wherein the arm unit enables the treatment tool to be detachable,

the ready mode includes:

a standby mode in which the arm unit is in a standby state in which the arm unit waits in a state before being operable by the operation unit and the synthetic image creation unit creates the synthetic image including the operation image; and

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a standby surgical device exchange mode in which the arm unit is in a state before being capable of being operated by the operation unit and the synthetic image creation unit creates the synthetic image including the operation image, the internal-body image, and the arm image in a state in which the treatment tool is exchangeable, and the standby exchange switching unit switches the operation mode set as the setting operation mode between the standby mode and the standby surgical device exchange mode by transmitting a signal to the mode control unit.

6. The surgical assistant system according to claim 5, wherein the synthetic image creation unit creates the synthetic image in which the operation image and the internal-body image are disposed at an edge of the arm image in the standby surgical device exchange mode.

7. The surgical assistant system according to claim 3, further comprising:

an emergency stop switching unit configured to switch the operation modes,

wherein the ready mode includes:

a standby mode in which the arm unit is in a standby state in which the arm unit waits in a state before being operable by the operation unit and the synthetic image creation unit creates the synthetic image including the operation image; and

an emergency stop mode in which an operation of the arm unit is forcibly stopped and the synthetic image creation unit creates the synthetic image including the operation image, the internal-body image, and the arm image, and the emergency stop switching unit switches the operation mode set as the setting operation mode between the standby mode and the emergency stop mode by transmitting a signal to the mode control unit.

8. The surgical assistant system according to claim 3, further comprising:

a driving exchange switching unit configured to switch the operation modes,

wherein the arm unit enables the treatment tool to be detachable,

the driving mode includes:

a driving normal surgical device mode in which the synthetic image creation unit creates the synthetic image using the operation image and the internal-body image in a state in which the arm unit is operated by the operation unit; and

a driving surgical device exchange mode in which the treatment tool is exchangeable and the synthetic image creation unit creates the synthetic image including the operation image, the internal-body image, and the arm image in the state in which the arm unit is operated by the operation unit, and

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the driving exchange switching unit switches the operation mode set as the setting operation mode between the driving normal surgical device mode and the driving surgical device exchange mode by transmitting a signal to the mode control unit.

9. The surgical assistant system according to claim 8, wherein the synthetic image creation unit creates the synthetic image in which the operation image and the arm image are disposed at an edge of the internal-body image in the driving surgical device exchange mode.

10. The surgical assistant system according to claim 3, further comprising:

an electric energy switching imaging unit configured to be a part of the operation imaging unit; and

a driving electric mode switching unit configured to switch the operation modes,

wherein the treatment tool is divided into a nonelectric type surgical device that does not use electric energy and an electric type surgical device that uses electric energy,

the operation unit has an electric energy switching unit switching whether or not electric energy is supplied to the electric type surgical device as a part of the operation unit,

the electric energy switching imaging unit acquires an electric energy switching image that is an image including the electric energy switching unit,

the operation image includes the electric energy switching image,

the driving mode includes:

a driving normal surgical device mode in which the synthetic image creation unit creates the synthetic image using the operation image and the internal-body image in a state in which the arm unit is operated by the operation unit; and

a driving electricity treatment tool mode in which the synthetic image creation unit creates the synthetic image including the internal-body image and the electric energy switching image, and

the driving electric mode switching unit switches the operation mode set as the setting operation mode between the driving normal surgical device mode and the driving electricity treatment tool mode by transmitting a signal to the mode control unit.

11. The surgical assistant system according to claim 1, further comprising:

an arm imaging unit configured to acquire an arm image that is an image including the arm unit,

wherein the synthetic image creation unit creates the synthetic image by synthesizing images using the arm image.

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